Comparison of Mauna Loa Observatory And Hilo Radiosonde Meteorological Measurements

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INTRODUCTION

This report compares meteorological measurements taken automatically at Mauna Loa Observatory (MLO) with twice daily concurrent Hilo radiosonde measurements. Hilo is 25 km upwind of MLO. It is well known that MLO nighttime downslope winds and daytime upslope winds do not relate well to free tropospheric wind flow in the region of the Mauna Loa massive. The regular downslope winds bring nocturnal upper level air to the observatory site that allows MLO to make background atmospheric composition measurements most days of the year. Less well known is the fact that other surface meteorological measurements (such as temperature and dewpoint) may also differ considerably from free atmosphere (radiosonde) measurements at or near to the same altitude. For this study, it is assumed that both the radiosonde and MLO meteorological instruments are accurate and thus the data from each fully comparable. The MLO and Hilo radiosonde data for 1992 were acquired from the MLO data base maintained in Hilo.

MLO had an average station pressure of 680 mb during 1992. For ease of comparison, radiosonde data for the 700 mb level for 0 and 12 GMT (0200 LST and 1400 LST) soundings were compared to the MLO hourly average data for the same hours grouped by month. According to the Smithsonian Meteorological Tables, the 20 mb offset between MLO and the radiosonde data would produce a maximum temperature error of 1.5°C in dry air (i.e., cooler at MLO) and a lesser difference in wet air. One would expect little difference in humidity between MLO and the radiosondes at the same altitude and no difference in wind speed and direction due solely to the 20 mb height differential. But, the mass of the mountain and its dark color considerably distorts the MLO surface meteorological readings as shown below. This report should be considered as an early step towards quantifying and understanding some of these effects.

WIND DIRECTION

The effect of the mountain on wind direction was as previously known: air flow at MLO was northerly during the day and southerly at night, fairly independent of the free tropospheric air flow patterns (Figures 1 and 2). These results are considered a reality check and suggest that the MLO surface data was processed in a correct

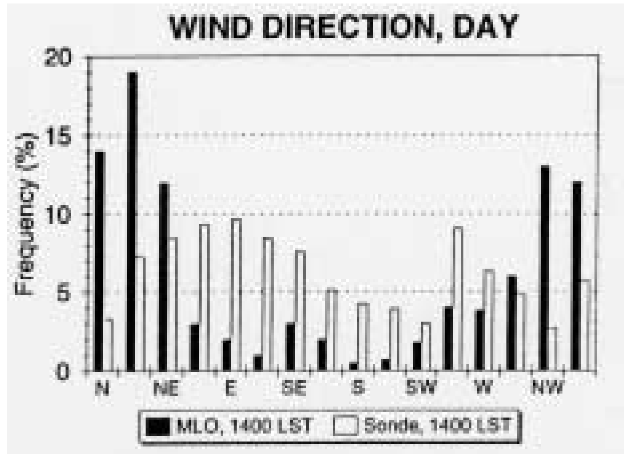

Fig. 1. Monthly average frequency of 700 mb winds measured at 1400 LST by the Hilo radiosonde in the free troposphere and the corresponding winds at MLO measured at 2 m above ground and 680 mb.

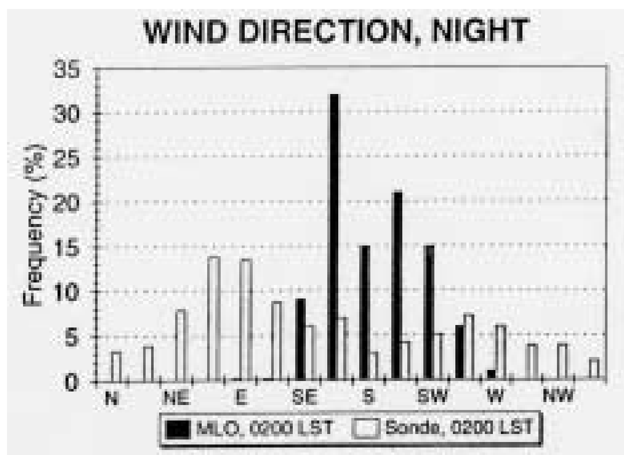

Fig. 2. Monthly average frequency of 700 mb winds measured at 0200 LST by the Hilo radiosonde in the free troposphere and the corresponding winds at MLO measured at 2 m above ground and 680 mb.

From the radiosonde data alone it may be observed that winds were most often flowing from an easterly direction night and day, but that there are diurnal effects in the 700 mb free atmosphere winds. Again this is nothing new and serves more as a confirmation that the radiosonde data was acquired and processed in a reasonable manner rather than a presentation of new science.

The daytime upslope winds at MLO presented in Figure 1 (hourly average winds at 1400 LST) are mainly from the northeast through northwest that slip under the free troposphere. It is worthy of note that the free troposphere winds over Mauna Loa are not exclusively easterly in direction.

At night (Figure 2) the downslope southeast through southwest winds dominate in a narrow 90° arc with negligible winds recorded in the northeast through northwest directions at 0200 LST. Like the upslope flows, these downslope winds slip under the free tropospheric flow and rush down the mountainside passing the observatory on a regular and highly predictable pattern.

AIR TEMPERATURES

The monthly average air temperatures at 0200 and 1400 LST recorded at 2 m above the surface at MLO compared to the concurrent radiosonde measurements are presented in Figure 3. From Figure 3 it may be observed that the MLO monthly average temperatures were 2-4°C warmer at 1400 LST and 2-5°C cooler at 0200 than the temperatures of the corresponding free atmosphere. There is a small diurnal cycle in the radiosonde data with slightly higher temperatures during the day and slightly cooler temperatures at night. The higher daytime temperatures at MLO are explained by the fact that the dark lava heats up during the generally cloud-free days that occur above the temperature inversion some 1200 m below the level of MLO. This warming drives the daily upslope flows that must be warmer than the free tropospheric air or they

Fig. 3. Monthly average air temperatures at 0200 and 1400 LST measured by the Hilo radiosonde at 700 mb in the free troposphere and at 680 mb and 2 m above ground level at MLO.

would not be rushing up the mountain each day. Both the surface heating effects and the warm air movements combine to produce the warmer daytime temperatures at MLO.

At night, the dark lava radiates heat to the clear sky and cools the air above it. This cooling drives the nightly downslope winds as the cool, dense air flows down the mountain slope. As observed in Figure 2, these downslope winds are pervasive, thus indicating that the air is always cooler at night at the surface at MLO than in the corresponding free atmosphere.

DEWPOINT TEMPERATURES

The dewpoint temperatures at MLO (Figure 4) exhibit a pattern of higher dewpoints in the day (i.e., more moisture in the air) than at night when the dry downslope air dominates. The relatively moist (and adiabatically cooling) upslope flow indicates that air influenced by the marine boundary layer is reaching the observatory during the day. It may also be observed in Figure 2 that the daytime radiosonde dewpoint temperatures are also generally slightly higher than the nighttime values. This is to be expected as the dewpoint temperature tendencies follow temperature in conservative, non-precipitating meteoro-logical situations.

CONCLUSIONS

Monthly average measurements of 1400 and 0200 LST wind directions, air temperatures and dewpoints at MLO are unrepresentative of the true state of the free atmosphere at the altitude of MLO. Thus, one should be cautious in using MLO surface meteorological data for climatological purposes. Follow-up studies should correct each data point for the 20 mb difference between the true air pressure at MLO and the standard 700 mb level radiosonde data. For the purposes of the current study, this 20 mb offset did not unduly obscure nor accentuate the much larger effects on meteorology produced by the mountain's topography and physiography.

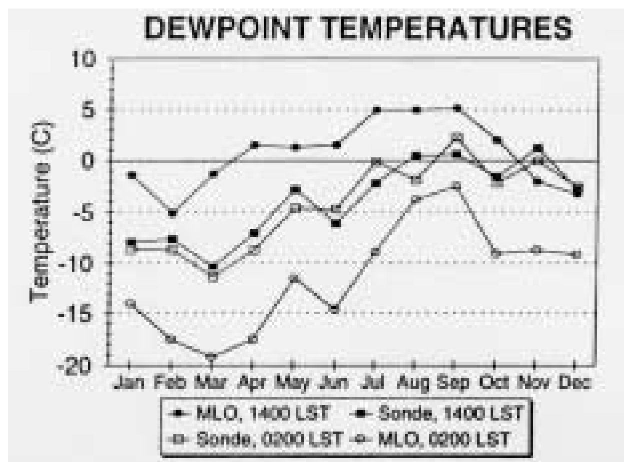

Fig. 4. Monthly average dewpoint temperatures at 0200 and 1400 LST measured by the Hilo radiosonde at 700 mb in the free troposphere and at 680 mb and 2 m above ground level at MLO.

*Eleanor was a student in the 1994 Hawaii Student Science Training Program held each year at the University of Hawaii, Hilo. She conducted her 10-day off campus research project at MLO under the supervision of Drs. John Barnes and Russ Schnell. Eleanor had completed grade 11 at the time of the study and plans on entering engineering school at MIT in the fall of 1995.